THE ABUNDANCE AND DISTRIBUTION OF HARD CLAMS IN NANTUCKET SOUND, MASSACHUSETTS 1958

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by

John W. Ropes
Fishery Research Biologist
Boothbay Harbor, Maine

and

Charles E. Martin
Fishery Methods and Equipment Specialist
Gloucester, Massachusetts

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ABSTRACT

A survey was made during the summer of 1958 to assess the abundance of hard clams, *Venus (Mercenaria) mercenaria,* in Nantucket Sound, Massachusetts. A jet (hydraulic) dredge was used as the principal sampling gear. Data from 214 sample stations compared with other Atlantic coast areas indicated that the abundance of hard clams in Nantucket Sound was extremely low. The survey revealed no new general areas of commercial abundance. No clams less than 60 millimeters (2 3/8 inches) were caught. Because of hydrographic conditions unfavorable for spawning and setting and because there are few small clams to augment the present stocks, the future of this fishery is uncertain.

The Sixteenth Annual Report of the Atlantic States Marine Fisheries Commission (1958) requested the Fish and Wildlife Service to make a census of the hard clam population in the Nantucket Sound area. This request was presented by shellfish industry members interested in knowing the potential of the present hard clam fishery in this area, where the catches have been important in augmenting the canners' supplies of large hard clams obtained from the inshore areas of Massachusetts and Rhode Island.

There has been a commercial fishery for hard clams or quahogs, *Venus (Mercenaria) mercenaria,* in Nantucket Sound for at least 50 years. Belding (1931) stated: "To the north of Nantucket in deep water extensive dredging was carried out between 1912 and 1915 over an area of several square miles which was thickly set with large clams. After several years' fishing this bed was practically exhausted." He also described dredges similar to the Fall River, Nantucket, and rocker dredges used today. Mr. Byron Blount of the Blount Seafood Corporation has told us that this area has been fished sporadically with Nantucket dredges since 1940. It was not until 1956 that Captain Arnold Veek used a jet dredge for the first time on these clam beds. The increased yield and efficiency of the jet dredge over other types explain the interest in its continued use in this area where at present, a fleet of five vessels use the dredge. Practically all of the hard clams caught by these vessels are larger than 90 millimeters (3 1/2 inches). The sizes are highly uniform, even though the diameters of the dredge bag rings vary from 2 to 3 1/2 inches.

During the summer of 1958 a survey was made to estimate the potential of the hard clam resources of Nantucket Sound. The purposes of this survey were (1) to establish the location, abundance and size composition of the large clams presently being fished, and (2) to determine if small clams exist in the area.

The survey was conducted by Clam Investigations and North Atlantic Fisheries Exploration and Gear Research of the Bureau of Commercial Fisheries. We wish to acknowledge the assistance of Captain Stanley T. Spink, Narragansett Marine Laboratory, University of Rhode Island, and Mr. Thayer C. Shafer, Massachusetts Department of Natural Resources, Division of Marine Fisheries. In the operation of the Bureau of Commercial Fisheries vessel *PHALAROPE II* we had the assistance of these agencies and men.

METHODS OF SAMPLING

Gear

The size of the area and relatively low abundance of hard clams precluded the use of standard sampling devices. The jet dredge was selected as the principal sampling gear because of its success in obtaining hard clams commercially. This gear would also obtain samples which could easily be converted into bushels per tow, an abundance or density figure familiar to the industry. The M/V *Sunapee,* a commercial jet dredge boat, with an experienced captain and crew, was chartered from June 2 to August 31, 1958. Captain Arnold Veek, her owner, has had extensive experience operating a jet dredge and was familiar with clam fishing in Nantucket Sound.

The jet dredge[1] used in this survey was developed in the 1940's to fish areas of hard bottom where the Nantucket and Fall River dredges would not operate effectively. It has since been used extensively on hard clams and on surf clams *(Spisula solidissima)* along the Atlantic coast.

Unlike the Nantucket and Fall River dredges, the jet dredge uses water jets to loosen the bottom sediments ahead of the digging blade (fig. 1). Water is supplied to the jets through a 5-inch hose attached to a powerful salt-water pump on the deck of the dredge boat. At 80 to 90 pounds pressure per square inch this pump will deliver about 125 gallons of water per minute.

[1] A more detailed description of the jet dredge is to be presented in a subsequent issue of Commercial Fisheries Review.

Figure 1. Bottom view of the forward cage of a jet dredge

The 40-inch wide digging blade at the mouth of the dredge has an attached inclined rack of iron rods that extend to the rear of the first cage. This blade can be adjusted up or down to vary the digging depth. The inclined rack serves to pass shellfish into the dredge. Two steel frames or cages form the bulk of the dredge and support the jet manifold, cutting blade and mesh bag. These cages slide along the bottom on broad flat runners (fig. 2).

In fishing, the 1,000-pound dredge is lowered by the main winch and a 5/8-inch wire cable attached to a ring on the forward cage towing bar. For safety in case of catching on bottom obstructions, the actual towing is done with a 1-inch manila line. The dredge is towed at slow speeds against the tide to keep it on the bottom and digging nearly all the time. After towing, the dredge is raised to the surface and a line is attached to a chain bridle on the rear cage. This line is used to raise the rear end of the dredge above the deck so it can be dumped (fig. 3).

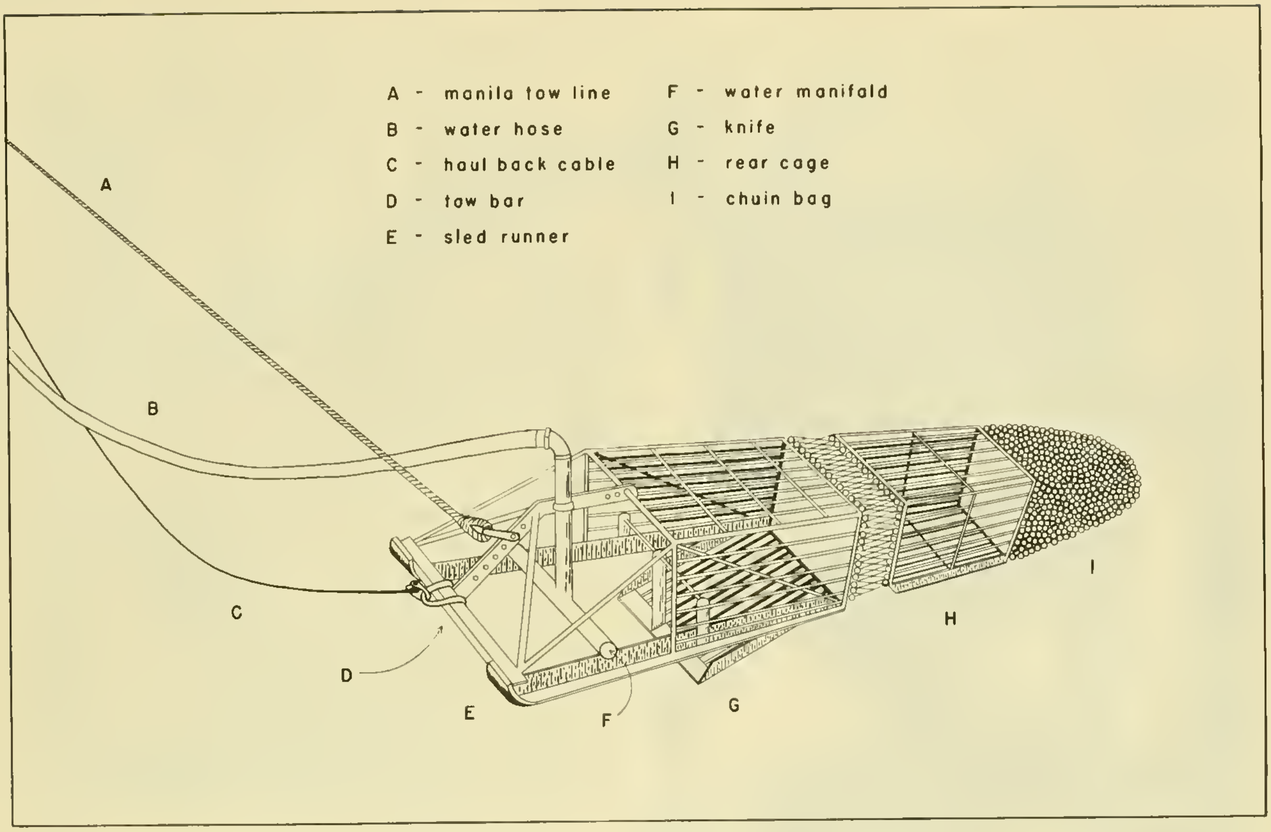

Figure 2.--Diagramatic sketch of a jet dredge

Sampling Stations and Procedure

Since specific knowledge of the location and distribution of the hard clam beds in Nantucket Sound was not available a grid pattern of sampling stations was employed. The stations were located 1/2 mile apart north and south and 1 mile apart east and west. During the time limit of the vessel charter, 214 samples were taken. The sample stations were distributed throughout most of the area where clams were believed to exist and where the dredge could be operated. Commercial fishermen indicated that many parts of the Sound were unsuitable for jet dredge operations because currents are fast and bottoms hard. These areas were therefore eliminated from the survey. Echo sounder traces showing the bottom topography and charts showing the bottom composition and current speeds were also used to delimit unsuitable dredging areas.

To obtain comparable results sampling tows of 20 minutes duration were made at each station. The area sampled was approximately 4 feet wide and 2,640 feet long or about 10,500 square feet. Loran bearings to determine position and echo sounder traces for depth and bottom topography were taken at each station. Otherwise, the jet dredge was operated according to standard commercial practices. The cutting blade of the dredge was set at 5 1/2 inches throughout the survey.

Since the sampling tows were based upon the dredge's being on the bottom 20 minutes and since the standard unit of catch employed by the fishermen is the numbers of bushels of clams caught per 1-hour tow, it is necessary to convert the sample catches to amounts comparable to those obtained in the fishery. The fishermen customarily tow the dredge on the bottom for 50 minutes and the remaining 10 minutes of the 1-hour tow is employed in raising, dumping, and resetting the dredge. Sampling tows were converted into bushels per commercial 1-hour tows by the following calculations: the number of hard clams caught at each sample station was multiplied by 2 1/2 to convert to 50 minutes fishing time and then divided by 83, the average number of clams of the sizes caught in a bushel. The term bushels per 1-hour tow will be used throughout this paper to mean bushels per commercial 1-hour tow.

Figure 3.--Dumping the dredge

Three 50-minute tows were made over bottom previously sampled by three 20-minute tows to determine if catches were proportional to time. The numbers of clams caught for each 50-minute tow were 640, 665, and 334. The corresponding 20-minute tows caught 311, 319, and 189 clams respectively. The catches of the 20-minute tows converted to 50-minute tows were larger than the catches of the 50-minute tows by 21.5, 19.9, and 41.5 percent respectively. In other words, the catches of clams may not be proportional to time; however, the variation in catch for each of the above tows was large.

Since so few observations were obtained upon which to base a decision, the conversion factor of 2 1/2 was used, with the realization that the actual concentrations of clams may be less than is reported. As will be seen, a lower conversion factor would not affect the general conclusions about the fishery.

As the jet dredge, used for the major part of the survey, retains only the largest sizes, two different techniques were used to sample clams less than 90 millimeters (3 1/2 inches) in length. First, the rear cage of the dredge was lined with 1/2-inch mesh wire hardware cloth, and 3-inch stretched mesh cotton netting was laid in the bag to obstruct the ring openings. The unwashed contents of each drag were dumped onto the deck and searched for small clams. Second, as it proved impossible to line the dredge completely, a small clam-shell bucket was used from the *PHALAROPE II,* to sample two areas. The clam-shell bucket samples about 5 square feet of bottom and has been used successfully in Narragansett Bay, Rhode Island to sample all sizes of hard clams (Stickney and Stringer 1957). The two areas in Nantucket Sound sampled with the clam-shell bucket included stations that had been found to have dense concentrations of clams. Ninety-eight samples were taken in a grid pattern, separated from one another by 900 feet in both north-south and east-west directions, from each 1- by 2-mile area.

Numerous observations were recorded during the survey. All hard clams caught were counted. When a sample contained more than 1 bushel of clams, the lengths of clams in 1 bushel were measured. If less than a bushel of clams were caught, the whole sample was measured. Observations were made of the sediments adhering to the dredge after each drag, presence of other animal species, water temperature at the surface and bottom, and the total amount of clam breakage. Meat yield was determined for some samples in terms of pounds of shucked, drained meats per 80-pound bushel of whole clams.

ABUNDANCE AND DISTRIBUTION

Figure 4 shows the Nantucket Sound area, the location of the various shoals and the 5-fathom-depth contour line. This line seems to separate roughly the hard clam producing areas since most of the clams were found below the 30-foot depth.

The locations of 214 stations sampled with the unlined jet dredge are presented in figure 5. Each station represents a tow of about 1/2 mile, made in 20 minutes. The abundance of clams, in bushels per 1-hour tow, is also included for each station.

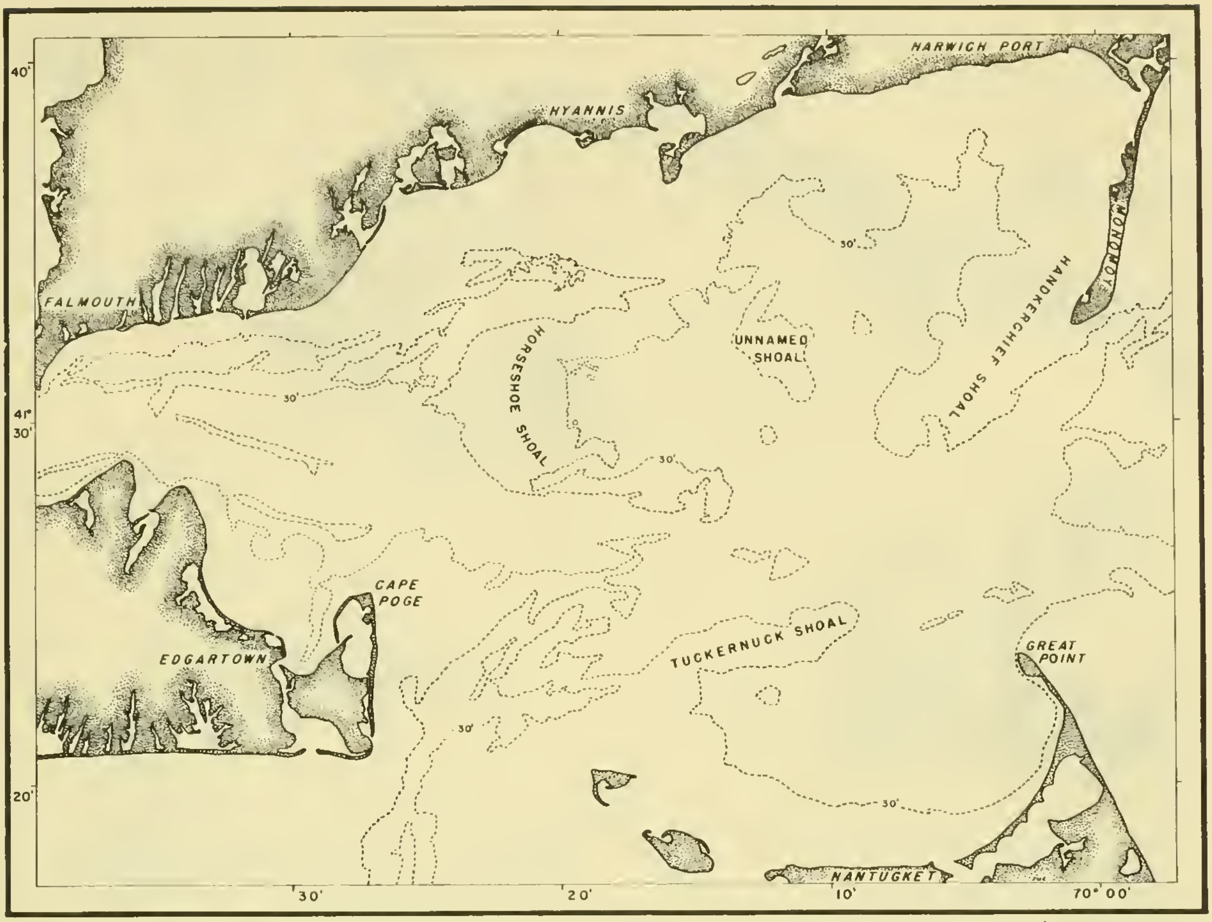

Figure 4.--Nantucket Sound, showing important shoals and the 5-fathom-depth contour line

The locations of samples taken with the lined jet dredge, stations where clams were obtained for meat yields, and the two areas sampled with the clam-shell bucket are also shown.

Figure 6 shows the abundance and distribution of hard clams in the areas of Nantucket Sound surveyed. Isopleths were drawn to include the following population density groups in units of bushels per tow: zero, to represent areas where no clams were caught; 0.1 or less to 0.9, low abundance; 1.0 to 4.9, moderate abundance; 5.0 to 7.9, abundances approaching commercial quantities; 8.0 to 10.9, commercially fishable quantities; and 11.0 or more, areas of particular commercial importance. The population density contours of figure 6 represent the best estimate of the distribution of hard clams based on the samples taken.

Nantucket Sound was divided into three general areas for convenience of discussion. These are well separated from one another by bottom that is probably unsuitable for hard clams. These are (1) the Horseshoe Shoal-Monomoy Point area, (2) the Tuckernuck Shoal-Great Point area, and (3) the Edgartown area.

Horseshoe Shoal-Monomoy Point Area

The Horseshoe Shoal-Monomoy Point area is the largest and most important of the three areas of the Sound surveyed, covering approximately 60 square miles. Hard clams were found in this area in very low abundance. Even though 84 percent of the 118 samples taken here yielded some clams, only 2.5 percent produced 8 or more bushels per tow (table 1). The highest concentration encountered was 13.7 bushels per tow.

The shallow unnamed shoal which lies in the middle of the relatively deep-water bight enclosed between Horseshoe Shoal and Monomoy Point effectively separates the hard clam producing area into two

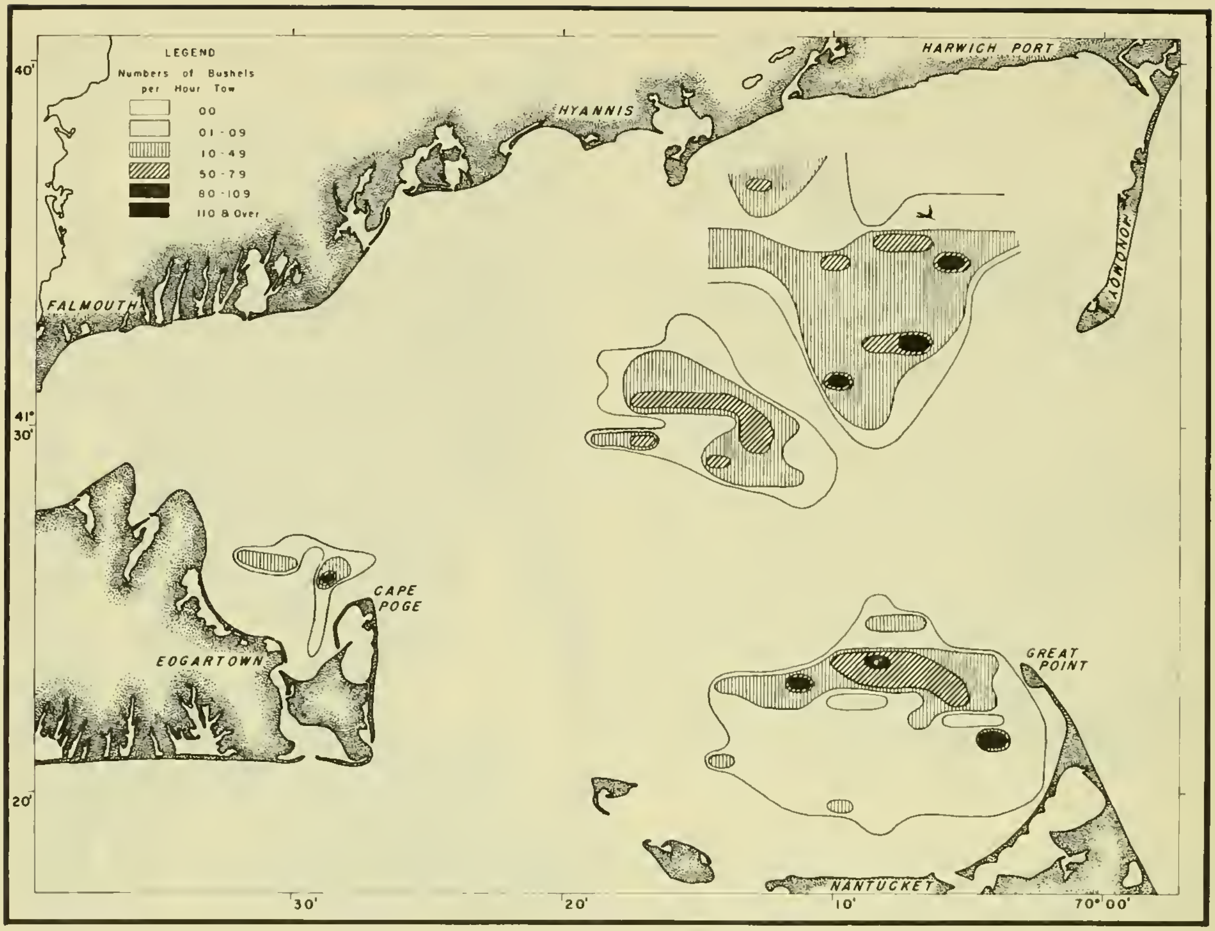

Figure 5.--Locations of survey stations and clam abundance in bushels per 1-hour tow

parts. Nearly half of all the samples having no hard clams were located on that shoal. The bottom sediments are sand, sand-mud and sand-mud-shell mixtures. Yellow sulfur sponges, *Cliona sp.*, and tunicates, *Amaroucium sp.*, occurred in abundance on and near this shoal.

The section between the above unnamed shoal and Monomoy Point had an average clam abundance of 2.3 bushels per tow. The greatest single sample of population density of this area (13.7 bushels per tow) was taken in this section. The high concentrations of clams were scattered in six widely separated places throughout this section. The sediment mixtures here contained more mud than sand. Shell was also mixed with the bottom material in some places. In the northeast corner a low abundance of clams were found in a soft mud bottom.

The average abundance of clams in the section between Horseshoe Shoal and the unnamed shoal was 2.1 bushels per tow. None of the samples had concentrations of hard clams over 8 bushels per tow. Although hard clams were moderately abundant in this section, it could not be considered a profitable area to fish commercially. The greatest number of clams were obtained from bottom sediments of a firm sand-mud mixture. No sediments were obtained in the dredge in the places of low clam concentrations. The bottom was probably sand which washes through the dredge rings readily and is not brought up with the gear.

In addition to hard clams, the following animals were frequently caught in both sections of this area: whelks, *Busycon sp.;* starfishes, *Asterias sp.;* and horseshoe crabs, *Limulus polyphemus.*

Tuckernuck Shoal-Great Point Area

Based upon an average concentration of hard clams of 1.9 bushels per tow, the

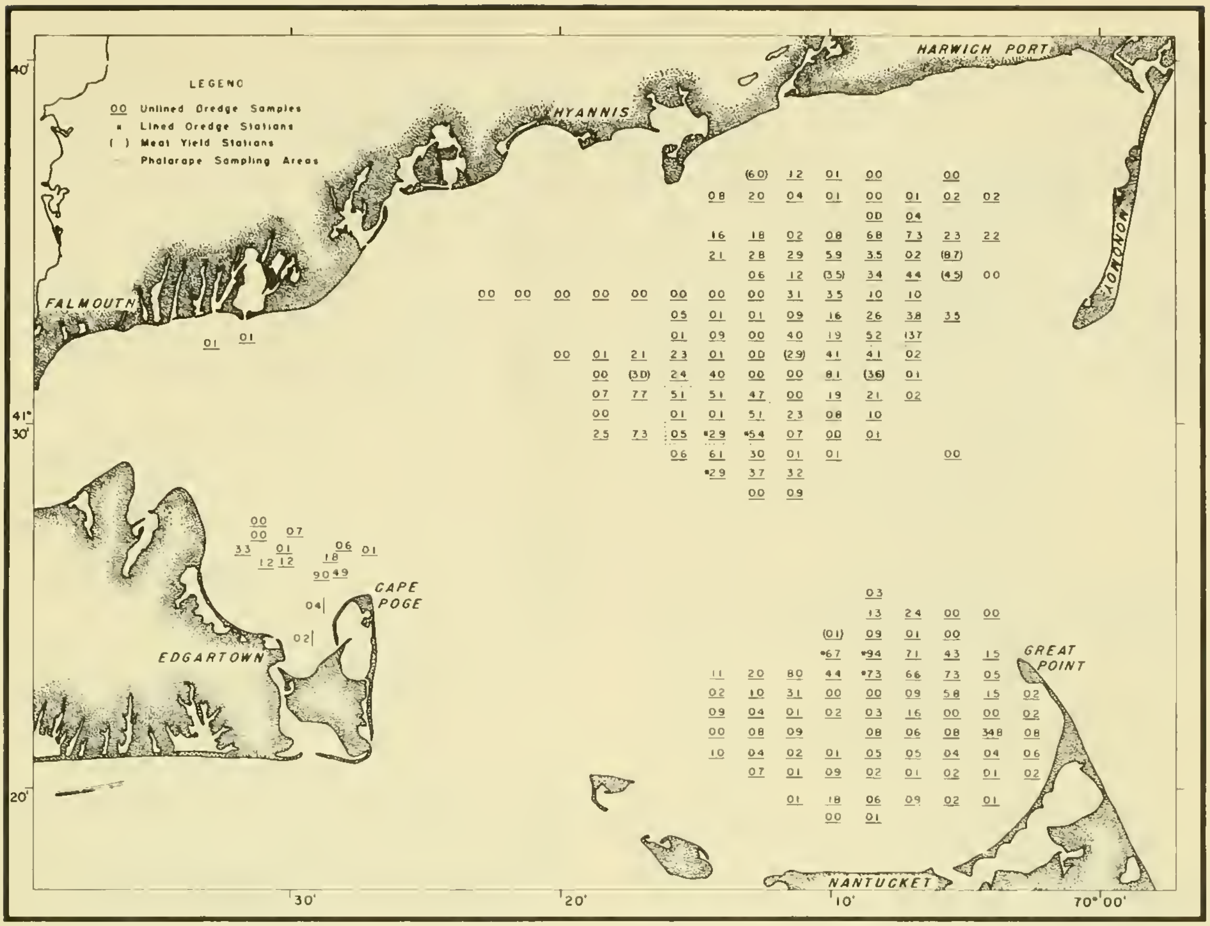

Figure 6.--Hard clam distribution in Nantucket Sound

Tuckernuck Shoal-Great Point area is the next most important of the three general areas surveyed. It had the highest single sample of the entire survey, 34.8 bushels per tow. In general, hard clams were spread over the entire area in relatively low abundance. Most of the large catches, however, were made on one rather extensive bed. Of the 75 samples taken in the area, 87 percent contained hard clams (table 1), but only 4 percent of the samples contained commercial quantities of clams, *i.e.*, over 8 bushels per tow.

The sediments in the places of higher clam concentration were principally firm sand-mud mixtures. Some rocks were found near the eastern tip of Tuckernuck Shoal. The low concentrations of clams in the center of the area were associated with soft mud sediments. The shoal water near Nantucket Island had sediments of a sand-mud mixture containing some rock and shell.

Where major population densities of clams were found, the whelks, *Busycon sp.*, and moon shells, *Lunatia (Polinices) heros* were frequently caught. In the muddy areas the dredge brought up hundreds of parchment worms, *Chaetopterus pergamentaceus*, and their tubes.

Edgartown Area

The Edgartown area lies in the bight between Oak Bluffs and Cape Poge and is the approach to Edgartown Harbor. This is the least important of the three general areas since the average density was 1.7 bushels per tow. Of the 14 samples taken in this area, 86 percent contained hard clams (table 1) but only 7 percent of the samples contained commercial quantities of clams. The major clam concentrations were found north of Cape Poge in more than 30 feet of water.

Clam concentrations occurred in sediments of sand-mud mixtures, with rocks and shell in some of the samples. Whelks, *Busycon sp.*, and horseshoe crabs, *Limulus polyphemus*, were also found in these places.

Table 1.--Population density groups by area

	Population density groups in bushels per tow						
	0.0	0.1-0.9	1.0-4.9	5.0-7.9	8.0-10.9	11.0 & over	Total
Number of samples from:							
Horseshoe Shoal-Monomoy Point area	19	35	49	12	2	1	118
Tuckernuck Shoal-Great Point area	10	42	14	6	2	1	75
Edgartown area	2	6	5	0	1	0	14
Percent of samples taken from:							
Horseshoe Shoal-Monomoy Point area	16.1	29.7	41.5	10.2	1.7	0.8	100.0
Tuckernuck Shoal-Great Point area	13.3	56.0	18.7	8.0	2.7	1.3	100.0
Edgartown area	14.3	42.9	35.7	0.0	7.1	0.0	100.0
Average number of bushels per hour:							
Horseshoe Shoal-Monomoy Point area	0.0	0.3	2.8	6.1	8.4	13.7	2.23
Tuckernuck Shoal-Great Point area	0.0	0.4	2.3	6.8	8.8	34.8	1.90
Edgartown area	0.0	0.4	2.5	0.0	9.3	0.0	1.71

Other Areas Sampled

With the exception of the three areas already discussed, fishermen reported that much of Nantucket Sound is unsuitable for jet dredge operations. Several attempts were made, however, to locate new beds of hard clams. For instance, two tows were made off Falmouth but the bottom there was rocky and unsuitable for efficient jet dredge operation. Four large, old clams were caught. These had the same general size as clams elsewhere in the Sound. Five tows were made in the area between Bishop and Clerks Shoal and Wreck Shoal, but only rocks were obtained.

Echo sounder tracings indicated that a strongly rippled bottom exists between the Horseshoe Shoal-Monomoy Point area and the Tuckernuck Shoal-Great Point area. These ripples reached 5 feet in height and are probably the result of rapid tidal currents. One tow was attempted just south of Handerchief Shoal, but the tide was so swift that the vessel was forced off course and the dredge did not operate successfully. The strong tidal currents and shifting bottom probably make these areas completely unsuitable for hard clam setting and survival.

SIZES OF HARD CLAMS CAUGHT

More than 7,000 hard clams, of the nearly 16,000 caught with the unlined jet dredge, were measured. The average size was 111 mm. (4 3/8 inches). The sizes were uniform (fig. 7), with 95 percent of the clams between 94 mm. (3 3/4 inches) and 127 mm. (5 inches). The smallest clam caught was 61 mm. (2 3/8 inches), although all noticeably smaller clams were picked out of any sample remaining on deck after the bushel to be measured had been obtained. The largest hard clam measured was 144 mm. (5 5/8 inches).

SAMPLES FOR SMALL HARD CLAMS

Six samples were taken with a jet dredge lined to retain small clams. The three samples from the Horseshoe Shoal-Monomoy Point area (fig. 5) contained only large clams. The small amount of sediment clinging to the dredge indicated a predominantly sandy bottom. The three samples from the Tuckernuck Shoal-Great Point area had only large hard clams. However, large masses of sand-mud sediments were retained in the dredge. Search through

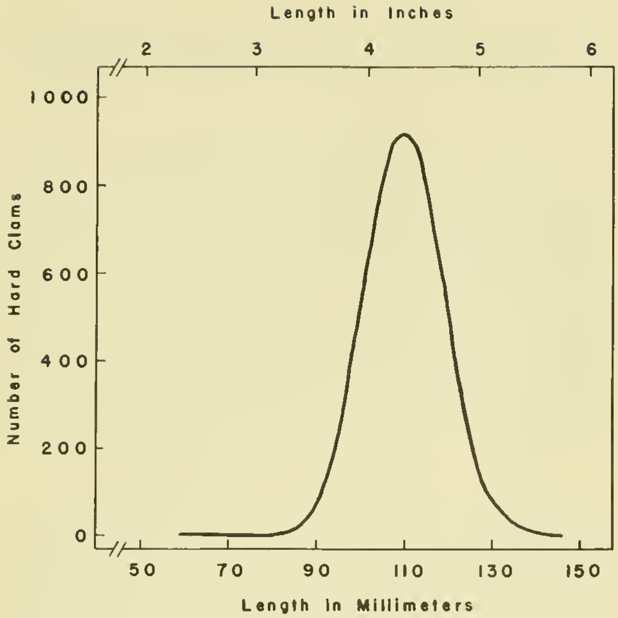

Figure 7.--Size distribution of Nantucket Sound hard clams smoothed by a moving average of three

these sediments on deck revealed many characteristically small mollusks such as *Yoldia limatula* and *Nassarius trivittatus*, but no small hard clams. Razor clams, *Ensis directus*, 2 to 4 inches long were also abundant. The presence of these other small mollusks indicates that small hard clams could have been retained had they been present in the sediments.

To check further for the presence of small hard clams we took 196 samples with the clam-shell bucket in two places (fig. 5) in the Horseshoe Shoal-Monomoy Point area. No small clams were taken in these samples, although 12 large ones were caught. Ten other species of mollusks, most of which were less than an inch long, were found. Again these small mollusks indicate that small hard clams would have been caught had they been present in the sediments.

OBSERVATIONS ON MEAT YIELD

Measurements of meat yield from eight samples of clams were obtained during the survey. The locations of these samples appear in figure 5 and the meat-yield data are presented in table 2. While shucking out a sample, the meats were allowed to drain in a colander. Then the meats were placed in sealed jars and weighed in port. These data indicate that wide variations in meat yields can occur when clams are taken from various places in the Sound. Differences as great as 7 percent were obtained when comparisons of meat yields per 80-pound bushel were made for samples from widely separated areas. But even greater differences were apparent when comparing meat weights alone. For example, 40.4 percent more meat was obtained at station 5 than at station 4. The possibility that meat yields might be characteristic of certain areas could not be determined because of lack of sufficient data.

Table 2.--Meat yields per 80-pound bushel of clams, 1958

Date	Station number	Drained meat lbs.	Drained meat oz.	Percent of an 80-lb. bushel
June 5	1	8	0	10.0
June 7	2	8	0	10.0
June 9	3	8	0	10.0
June 11	4	7	12	9.7
June 26	5	13	0	16.3
July 17	6	11	8	14.4
July 18	7	11	8	14.4
July 18	8	12	8	15.6

DISCUSSION

The Nantucket Sound hard clam survey disclosed three important facts. First, the population densities of hard clams, even in the areas being commercially fished, were very low. Second, there were no hard clams smaller than 60 mm. in length. Third, no new hard clam areas of commercial abundance were discovered.

Low hard clams concentrations were expected on the basis of discussions with people having knowledge of the area, but the extremely low densities found by the survey were somewhat surprising. The area supports a commercial fishery only because of the efficiency of the jet dredge.

The extremely low population densities encountered in Nantucket Sound will be better comprehended by comparison with those from surveys made elsewhere along the Atlantic coast. Most of the other surveys report abundance in terms of the number of hard clams caught in a unit area of bottom, *e.g.*, number per 100 square feet. As the area covered by the jet dredge in the 20-minute sampling tow was known and the hard clams caught in each sampling tow were actually counted, it was possible to convert all samples to numbers per 100 square feet. The average population densities (table 1) for the three areas were 2.2, 1.9, and 1.7 bushels per tow. These are equivalent to 0.7, 0.6, and 0.5 hard clams per 100 square feet respectively. The two greatest abundances found were 13.7 and 34.8 bushels per tow, or 4 and 11 clams per 100 square feet.

In Chincoteague Bay, Maryland, Wells (1957) obtained a population density for clams 38 mm. (1 1/2 inches) or more in length as high as 68 clams per 100 square feet or over 6 times the highest density observed from Nantucket Sound. Even higher densities were obtained in Narragansett Bay, Rhode Island, when a survey was made of clams 15 mm. and larger (Louis D. Stringer, personal communication). Although the average density of 156 clams per 100 square feet obtained from the Providence River is 14 times greater than the largest density obtained for Nantucket Sound, one particularly large sample yielded 1,760 clams per 100 square feet. The Narragansett Bay density figures include clams 15 to 66 mm. in length and are not strictly comparable with Nantucket Sound densities. However, if only clams above 66 mm. are considered, the average density in Narragansett Bay was 21 per 100 square feet, a figure nearly twice as large as the highest single sample obtained in Nantucket Sound.

The absence of clams less than 60 mm. during this survey is of considerable concern with regard to the future of this fishery. Admittedly the evidence that small clams do not exist in Nantucket Sound is inconclusive since the whole area was not explored with gear what would effectively capture them. Yet if we suppose that clam sets equal to an average density of 1 clam per 100 square feet occurred and survived for any 1 year in the past 5, nearly 10 clams less than 60 mm. should have been caught in the 196 clam-shell bucket samples. Instead, none was caught, even though bucket samples were taken from bottom that had produced one of the largest catches of hard clams, *i.e.*, the one tow yielding 4 clams per 100 square feet. This would lead to the assumption that the occurrence or survival of young clams must be lower than 1 clam per 100 square feet.

One of the important reasons for the hard clam survey was to discover any areas of commercial abundance not already known to the fishermen. No new commercial areas were found. The various general areas where hard clams could be found were known. However, the exact locations of heavy concentrations were not completely known and defining these areas accomplished an important purpose of the survey.

Two theories could account for the occurrence of the present population of hard clams in Nantucket Sound. First, these clams could have occurred because of successful setting at infrequent intervals, resulting in dominant year classes. Second, the present abundance may be the accumulation over many years of a very few offspring which set and survive each year.

Since female hard clams have a high reproductive potential and can produce an average of 25 million eggs each spawning season (Davis and Chanley 1956), relatively few adults are needed to produce large numbers of offspring when particularly favorable environmental conditions occur. In general, particularly favorable conditions do not occur each year, but when they do the resulting offspring are so numerous in comparison to the numbers produced in other years that they result in a dominant year class. A dominant year class is characterized by a relatively large number of individuals that are the same age and nearly the same size.

Of the physical, chemical, and biological conditions, water temperature has a particularly limiting effect upon hard clam reproduction. Spawning does not take place at temperatures below 69° F. (Loosanoff and Davis 1950). Turner (1957) reports that bottom water in the middle of Nantucket Sound rarely reaches this temperature even in midsummer. Therefore, conditions for the production of a dominant year class in Nantucket Sound may occur only in those rare years when the water temperature goes above 69° F. and when all other environmental conditions are suitable for the survival of offspring.

It is not possible to determine whether the Nantucket Sound population is the result of one or more dominant year classes. If dominant year classes were based upon size alone, the rather small difference in the sizes of hard clams might indicate a population resulting from successful reproduction in one or two years. Rough age readings of the more distinctly lined shells indicate a difference of 10 or more years in their ages. The hard clams of the Sound are very old (15 to 30 years) and they grow, in terms of shell length, very slowly. Blunting or thickening of the shell lips can result in individuals only a few millimeters different in size, but several years apart in age.

The preceding discussion would seem to favor the second theory that these old hard clams are the result of an accumulation of a few offspring that survive each year. The hydrographic data presented by Turner (1957) indicate that, even if these deeper water clams did spawn, the larvae would likely be swept into the open ocean before they developed to setting size. It is conceivable that a few larvae come from the inshore areas of Cape Cod, Marthas Vineyard, and Nantucket. Tidal currents could carry a few larvae each year from these inshore areas into the middle of the Sound. Some of these larvae might be sufficiently developed to set on suitable bottom, survive, and grow. Over a period of years a commercially abundant population of hard clams could be built up. But the abundance of any particular age group would be extremely low and as was seen in this survey, the young clams were not detected by the sampling methods used. Only when the very old individuals accumulated would the abundance become great enough to be detected. Studies in Greenwich Bay, Rhode Island, indicate that concentrations of large old clams can accumulate over a period of years from small numbers of individuals escaping the commercial fishery each year.

The Nantucket Sound hard clam populations may, then, be the result of dominant year classes or an accumulation over many years of a very few offspring which set and survive each year. Either of these theories, the interaction of both, or some other theory for which data are not yet available, might explain how these populations came into existence. Predators undoubtedly further reduce the clam abundance in the area. Samples taken during the survey indicated the presence of at least the following six hard clam predators: whelks, *Busycon caniculatum* and *B. caricum;* cockles, *Lunatia (Polinices) heros* and *Polinices duplicatus;* starfishes, *Asterias sp.;* and horseshoe crab, *Limulus polyphemus*. Other predators may also be present, but were not caught in the samples.

Since the hard clam concentrations of Nantucket Sound are so low and the repopulation of the area appears to be a slow or doubtful process, the future of the present fishery is uncertain. With present economic conditions, fishermen consider tows yielding less than 7 bushels unprofitable fishing. Only 7 samples taken during the survey indicated abundance greater than 7 bushels per tow. It is estimated that ninety-five 24-hour fishing days would reduce these areas to unprofitable population densities. As the numbers of small hard clams to augment present stocks appear to be nonexistent or at least very low, further exploitation would only continue to lower the concentrations of clams.

CONCLUSIONS

1. The abundance of hard clams in the areas of Nantucket Sound surveyed is extremely low as compared with other important areas of the Atlantic coast.

2. No hard clams below 60 millimeters were caught in the survey by any of the sampling methods used.

3. No new areas of commercial abundance were discovered by the survey.

4. The future of the Nantucket Sound fishery appears uncertain because hydrographic conditions are unfavorable for spawning and setting and because small hard clams to augment the present stocks are scarce.

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